AD-A263 045

Quarterly Progress Report, Sep 1992 – Nov 1992
ONR Contract Number N00014-91-J-1577
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We continue to explore issues in planning and sensing in realistic environments:

• We have been deepening the declarative aspect of plans expressed in our Reactive Plan Language. We implemented the BELIEF statement as a new declarative command. The belief statement makes more explicit the meaning of control decisions based on internal data structures, like the robot controller's position estimate, or the data structures describing the contents of the robot's hands.

We have begun the implementation of a notation for expressing plan transformations more declaratively. We call this "XFRM-ML," for "XFRM Meta-Language." It is a PROLOG-like language for the implementation of failure diagnosis and plan revision. XFRM-ML lets plans and their simulations appear as if they were PROLOG databases. Using XFRM-ML the planner can retrieve plan properties and happenings during simulation with transparent (PROLOG) queries that have a PROLOG-like semantics.

We have developed a small knowledge base for the detection and analysis of plan failures that can occur in the performance of an achievement task when it is carried out using *imperfect sensors, imperfect control*, an *inaccurate and highly incomplete world model*, and *with other tasks*.

• Work was done on comparing the performance of set-based and statistical estimation methods on a variety of typical robotics problems. The results suggest that there is a strong role to be played by set-based methods on certain types of characteristic problems. We also began to look more actively at the problem of visual tracking, and vision-based servoing. We have been able to formulate the vision-based servoing problem using an uncalibrated pair of stereo cameras in an unknown relationship to a robot arm using adaptive control, and have made steps towards showing that the problem is, in fact, solvable using these methods. The planning problem for feature-based visual servoing was examined, and a planning algorithm proposed. We are now in the process of implementing that algorithm. We have also continued our work on sensor-based decision-making, focussing largely on the segmentation problem.

• We continued work on our model of robot map construction. We developed and tsted an active method for finding distinctive views for image based place recognition. We completed and documented a new abstract robot simulator, ARS MAGNA. The world model is justified in terms of current robotics and vision research, and supplies a complex and realistic environment for testing and analysis of planning and learning systems. It is being used at other sites for simulating complex robot planning environments.

Activities:

Greg Hager: Towards task-directed planning of cooperating sensors (with G. Grunwald). Presented at the SPIE Sensor Fusion Workshop, 1992.

Greg Hager: Sensor planning for reactive robot programs (with G. Grunwald, invited) Pesented at the Allerton Conference on Control and Computing, 1992.

Drew McDermott and Sean Engelson: Attended AAAI Fall Symposium, Cambridge, September

Publications:

Sean P. Engelson, "Active Place Recognition Using Image Signatures". SPIE 1992.

Sean P. Engelson and Niklas Bertani, "ARS MAGNA: The Abstract Robot Simulator Manual" YALEU/DCS/TR-928.

Sean P. Engelson and Drew V. McDermott, "Maps Considered As Adaptive Planning Resources". AAAI Fall Symposium on Applications of AI to Real-World Autonomous Mobile Robots

Greg Hager, Sean Engelson, and S. Atiya. On Comparing Statistical and Set-Based Methods in Sensor Data Fusion (with S. Engelson and S. Atiya). Submitted to the International Conference on Robotics and Automation, 1993

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We are now conducting experiments to validate our approach to run-time planning. Results soon.

We are extending the XFRM-ML notation described above to handle more planning and temporal-reasoning constructs.

We will be transmogrifying our planning systems from the simple grid-world simulator to the more realistic ARS MAGNA simulator.

DTIC QUALITY INSPECTED 4

LEDGER DESCRIPTION	AMOUNT BUDGETED	COMMITTED (NOT PAID)	PAID TO DATE	TOTAL EXPENSES	REMAINING BALANCE
NON-LADDER ACAD& RES APPTS	0	2,686.23	2,686.23	5,372.46	-5,372.46
FACULTY SUMMER COMP	33,223		50,377.56	50,377.56	-17,154.56
CLERICAL & TECHNICAL	16,560	5,019.	26,582.59	31,601.59	-15,041.59
STUDENT ASST.	88,050	3,475.02	32,925.12	36,400.14	51,649.86
OTHER YALE STU-DENTS	0		15,632.	15,632	-15,632
DIRECT WAGES	0		344.	344.	-344.
EMP. BENEFITS	18,123.	2,601.04	24,954.04	27,555.08	-9,432.08
D/P SUPPLIES	0	404.	2,713.78	3,117.78	-3,117.78
D/P SVS.	24,840	10,804	14,231	25,035.	-195.
MINOR EQUIPMENT	0		379.	379.	-379.
MISC MATERIALS	0		55.17	55.17	-55.17
D/P SOFTWARE	6,000		2,633	2,633	3,367
FREIGHT & TRANSPORTATION	0	222.96	519.17	742.13	-742.13
PHOTOCOPYING	4,140	304.17	1,665.36	1,969.53	2,170.47

Personnel Support:

- *Graduate Students (full time):* Sean Engelson, Michael Beetz, and Pedro Marun

- *Post-doc (half-time):* Hemant Tagare

- *Secretary (half-time):* Paula Murano

Expenditures:

The accompanying table shows the figures for expenditures to date, including amounts committed but not actually spent.

Overall Status and Plans:

We are quite pleased with our productivity to date. Pity it has to end in a year.

LEDGER DESCRIPTION	AMOUNT BUDGETED	COMMITTED (NOT PAID)	PAID TO DATE	TOTAL EXPENSES	REMAINING BALANCE
PRINTING	0		313.80	313.80	-313.80
MISC SERVICES	0		270	270	-270
COMMISSIONS	0		25.	25.	-25.
D¶EQUIPMENT MAINT	0		581.16	581.16	-581.16
TRAVEL (DOMESTIC)	8,280	482.42.42	8,173.34	8,655.76	-375.76
TRAVEL (FOREIGN)	0		2,913.98	2,913.98	-2,913.98
OFFICE SUPPLIES	2,070	93.61	812.69	906.30	1,163.70
PERIODICALS	0	183.95	1,239.70	1,423.65	-1,423.65
POSTAGE	0	82.99	695.33	778.32	-778.32
TUITION REMISSION	44,532		25,416.	25,416.	19,116.
HEALTH INS.	0		1,444.	1,444.	-1,444.
TELEPHONE	2,070	60.66	392.52	453.18	1,616.82
DATA PROC. EQUIPMENT	139,000	10,638.	67,752.25	78,435.25	64,564.75
INDIRECT (OVERHEAD 68.0%)	138,282	17,965.64	130,940.34	148,905.98	-10,623.98
TOTAL:	525,170	55,068.69	416,668.13	471,736.82	53,433.18
OVERHEAD ANTICIPATED:					21,627.72

SPENDING BALANCE AVAILABLE AS OF 01/04/93:   31,805.46